Near-Earth Asteroids 2006 RH_{120} and 2009 BD: Proxies For Maximally Accessible Objects?

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Introduction

- Near-Earth Object Human Space Flight Accessible Targets Study (NHATS):
  - http://neo.jpl.nasa.gov/nhats/
  - As of mid-July 2015: 1,434 of the 12,778 currently known NEAs are more astrodynamically accessible than is Mars (requiring less Δv and or less flight time for round-trip missions)
  - Within those 1,434 NEAs:
    - 605 NEAs can be visited round-trip for less Δv (9 km/s) than the lunar surface
    - 51 NEAs can be visited round-trip for less Δv (5 km/s) than low circular lunar orbit
- NEO population statistical models:
  - Tens of thousands of NEAs $>$100 m yet to be discovered
  - At least several million NEAs $\leq$100 m in size (down to $\sim$3 m in size) yet to be discovered

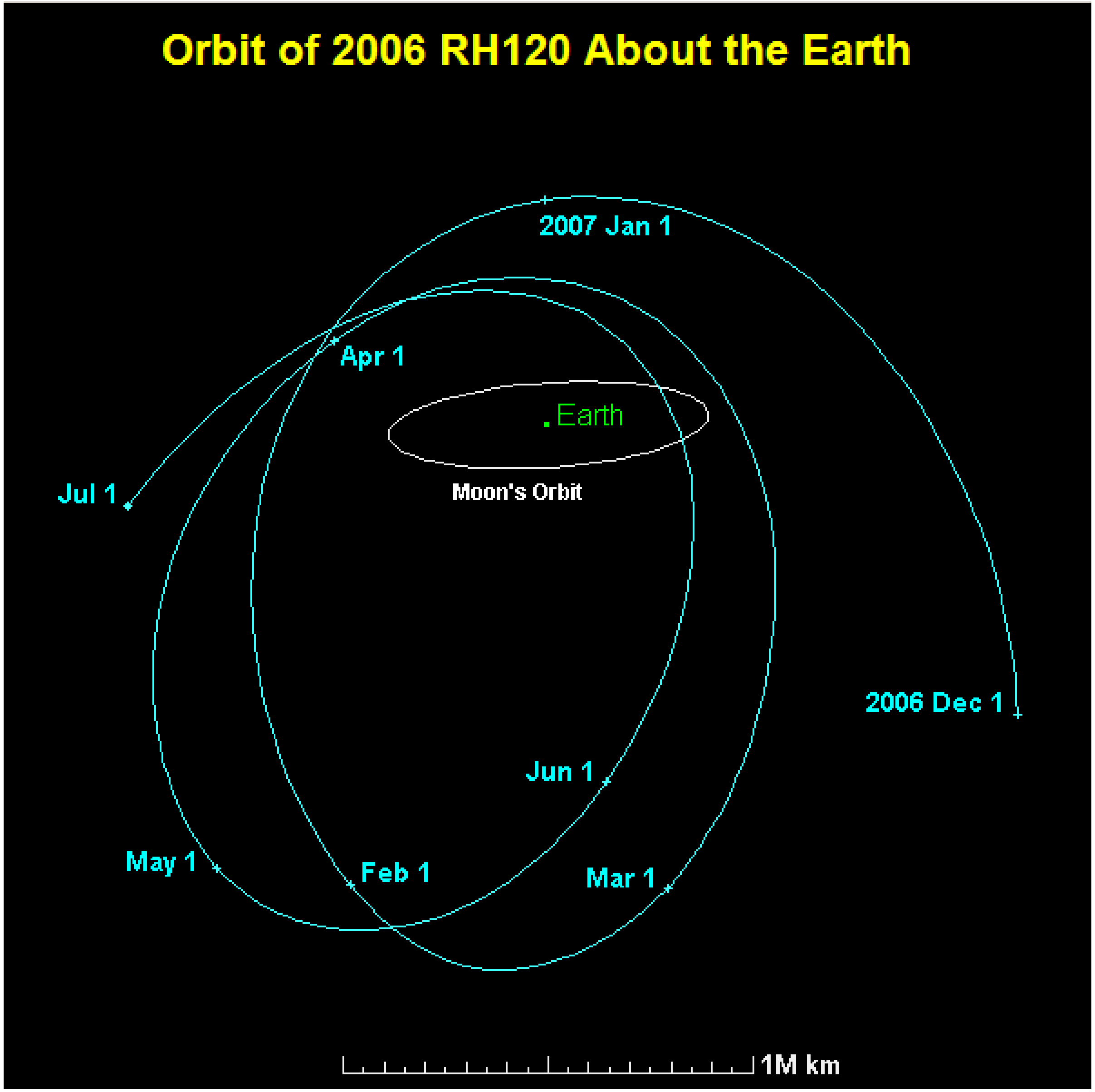
How accessible are the NEAs that haven't yet been discovered?

Highly Accessible NEAs

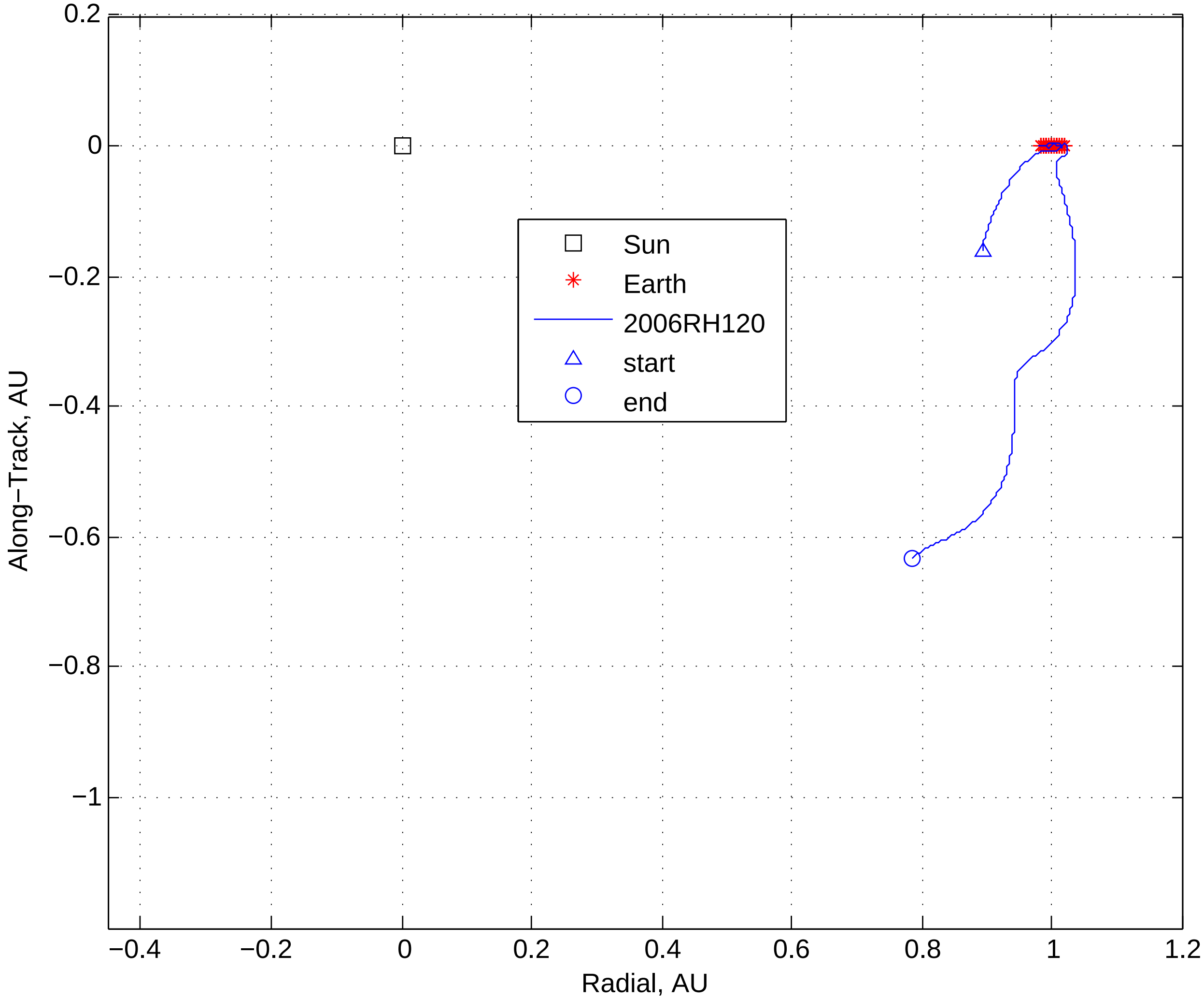
- The NHATS system evaluates NEA accessibility for Earth departure dates between 2015 and 2040
- However, some of the most accessible of the NHATS-compliant NEAs were at their most accessible when they were discovered
- Two NEAs that appear to have very high prior accessibility: 2006 RH_{120} and 2009 BD
  - 2006 RH_{120}
    - $\sim$2–3 m in size
    - Captured by Earth June 2006 to September 2007
  - 2009 BD
    - $\sim$4 m in size
    - Not captured by Earth, but still highly accessible in the past

Might these be suitable proxies for the most accessible of the not yet discovered NEAs?

Motion Relative to Earth: 2006 RH_{120}

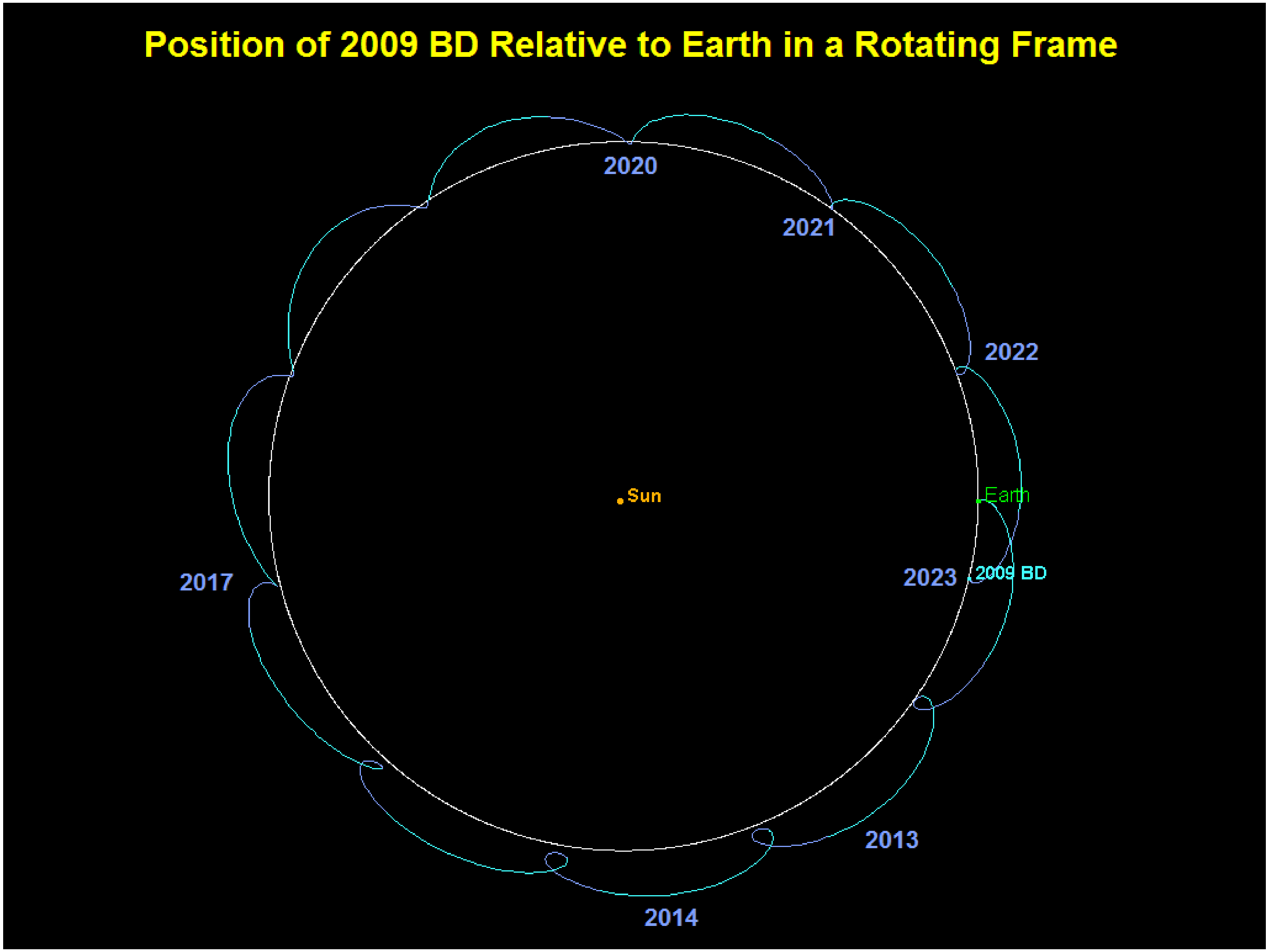


Motion Relative to Earth: 2006 RH_{120}

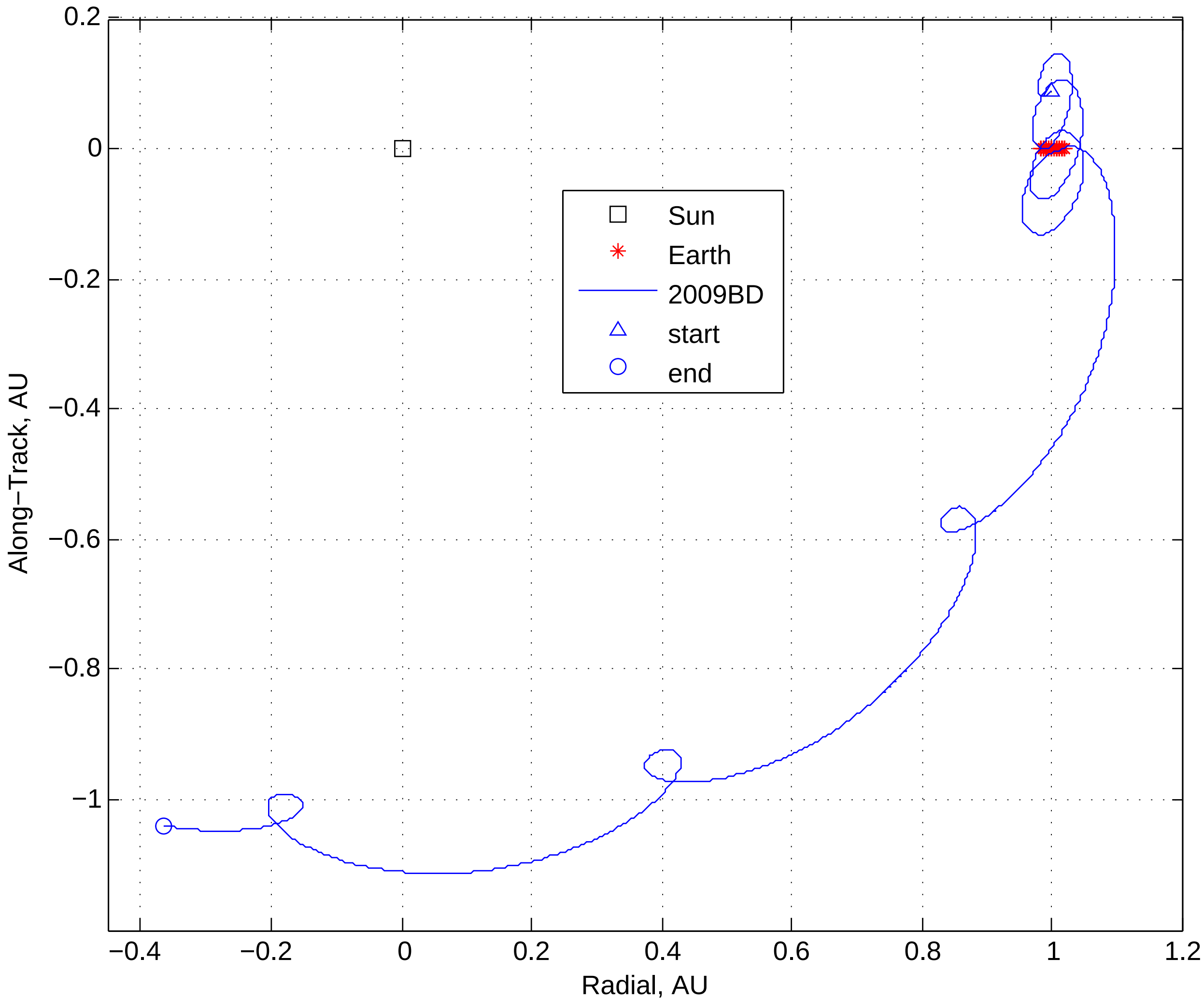


2006-01-01 to 2007-12-31

Motion Relative to Earth: 2009 BD

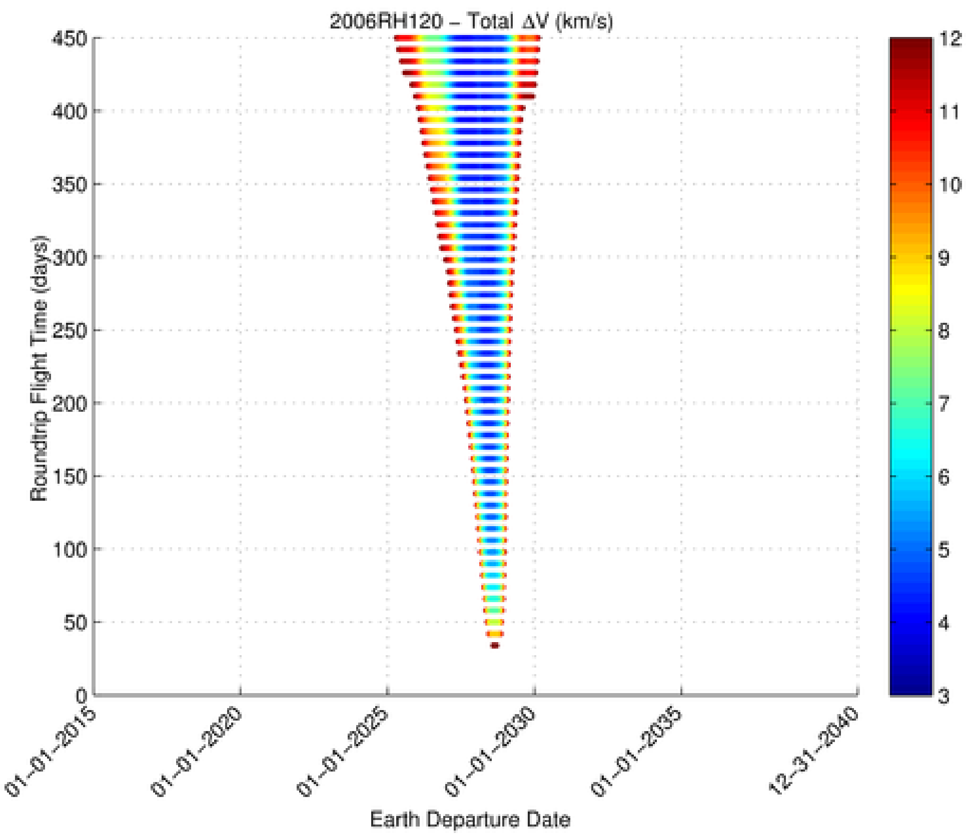


Motion Relative to Earth: 2009 BD

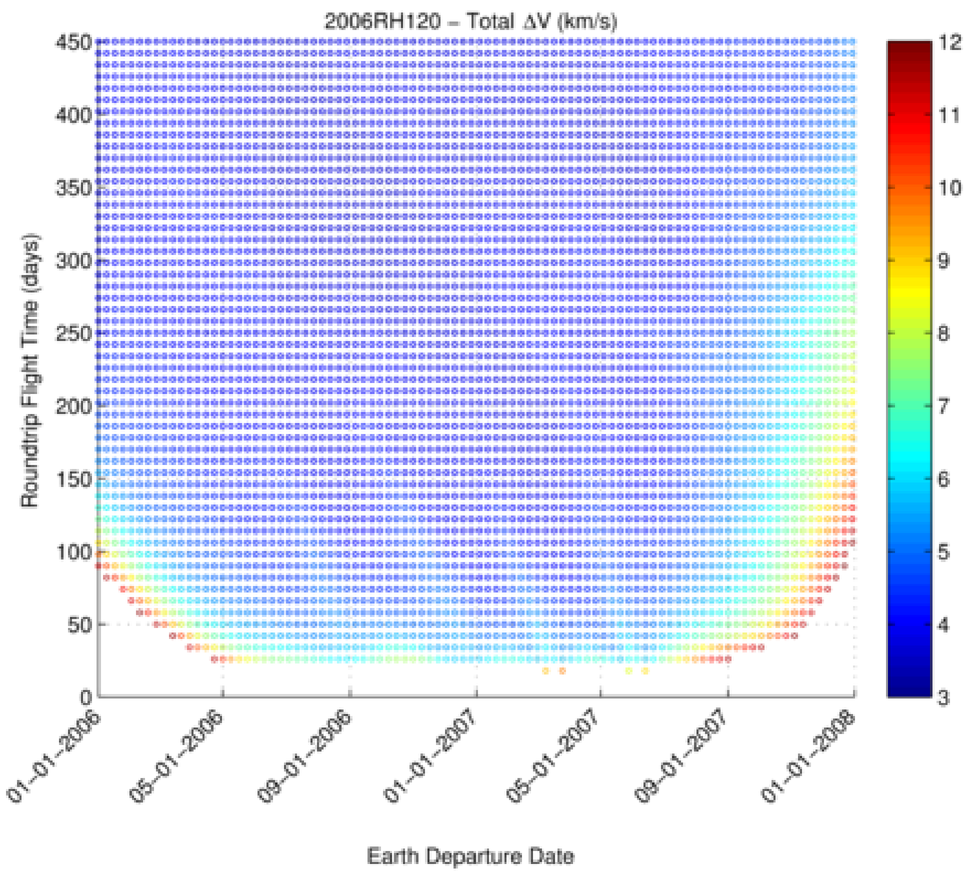


2008-01-01 to 2014-12-31

PCC Comparison: 2006 RH_{120}

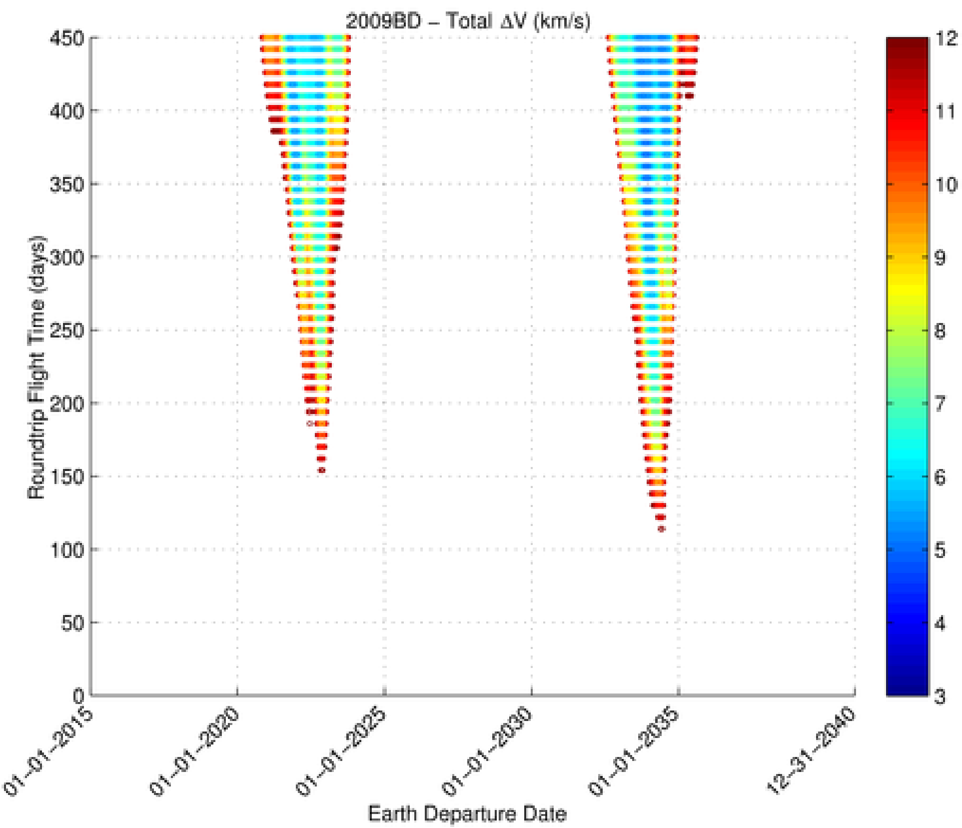


Standard NHATS Analysis 2015–2040

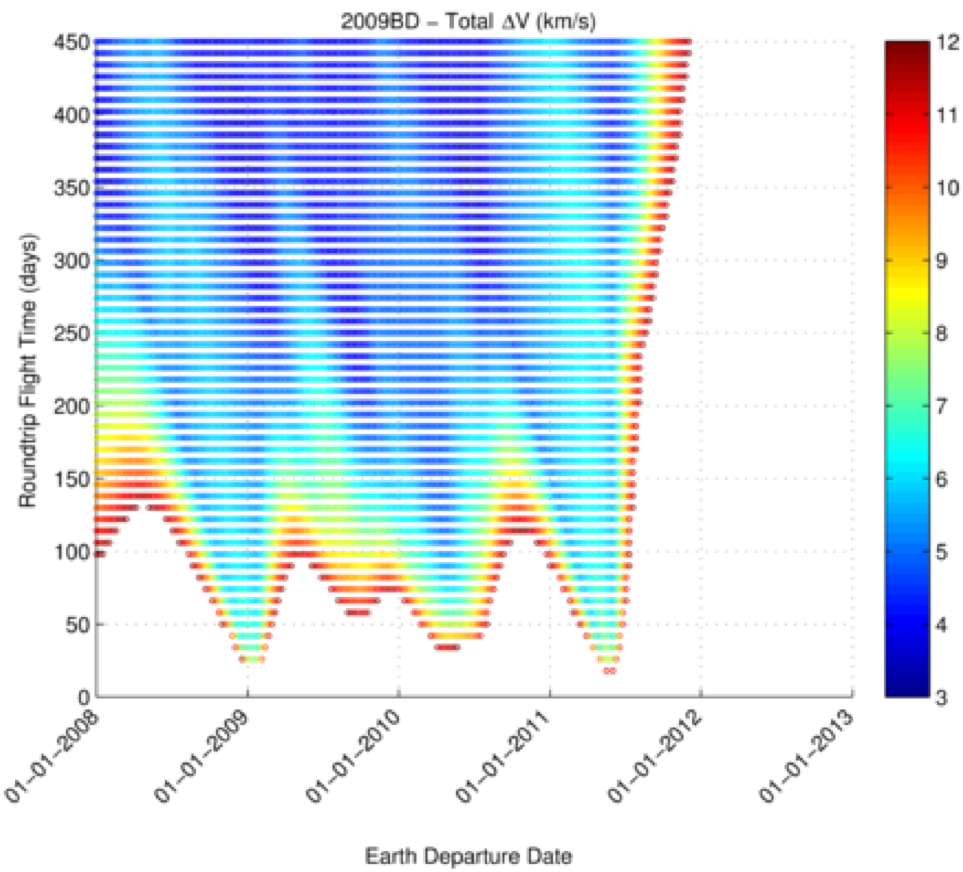


NHATS-like Analysis 2006–2007

PCC Comparison: 2009 BD



Standard NHATS Analysis 2015–2040



NHATS-like Analysis 2008–2012

Mission Trajectories Comparison

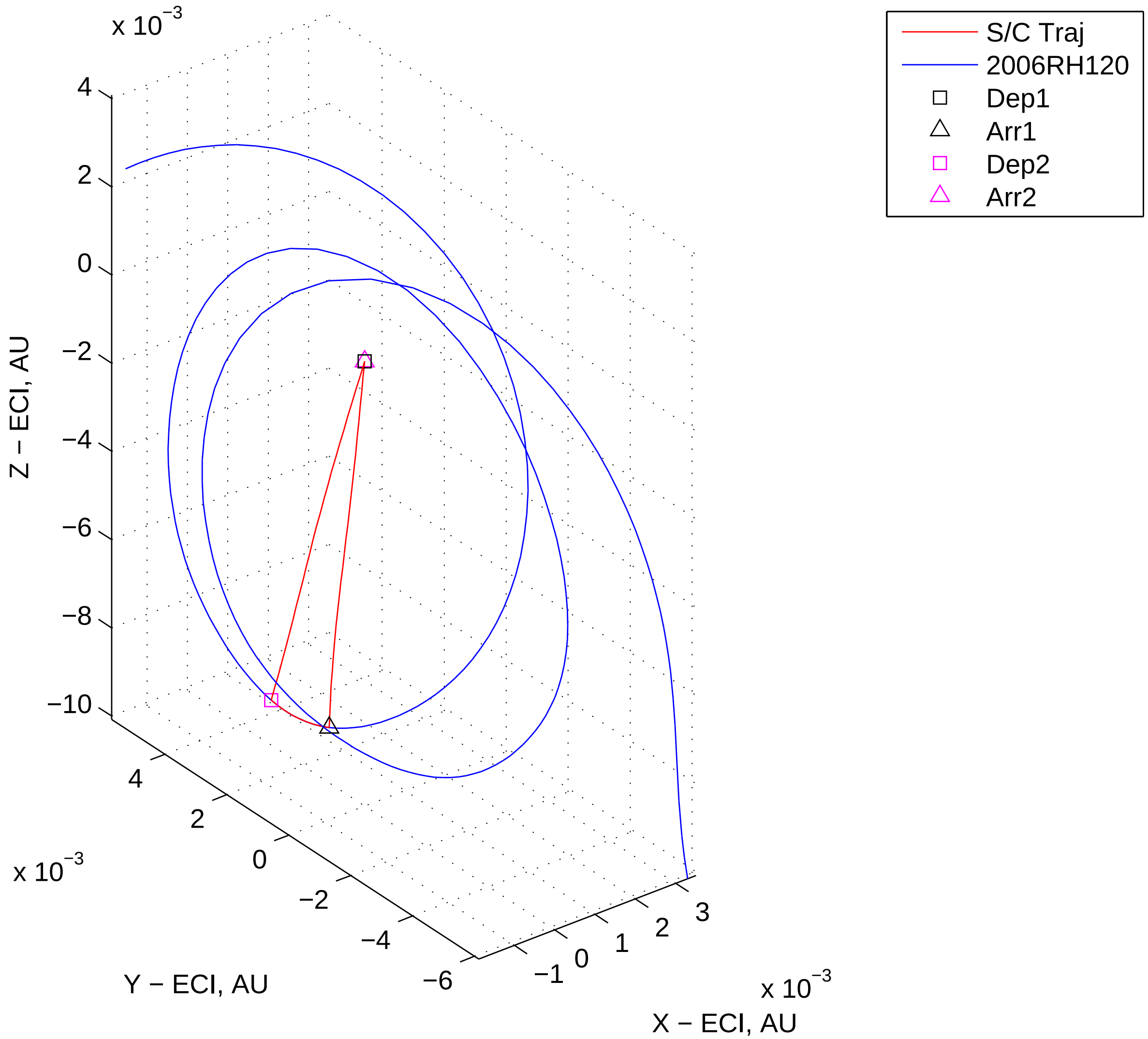
2006 RH_{120}

	$\Delta v \leq 12$ km/s, Dur ≤ 450 d				$\Delta v \leq 4.5$ km/s, Dur ≤ 150 d			
	2015–2040		2006–2007		2015–2040		2006–2007	
	Min. Δv	Min. Dur.	Min. Δv	Min. Dur.	Min. Δv	Min. Dur.	Min. Δv	Min. Dur.
Total Δv (km/s)	3.972	11.942	3.501	9.147	4.711	4.993	3.843	**4.451**
Total Duration (days)	450	34	386	18	146	122	146	**58**
Earth Dep Date	18-Aug-2027	4-Aug-2028	18-Jun-2006	9-Mar-2007	3-Jul-2028	3-Jul-2028	1-Mar-2007	**12-Jan-2007**
Return Entry Speed (km/s)	11.083	12.000	11.085	11.811	11.101	11.112	11.075	**11.091**

2009 BD

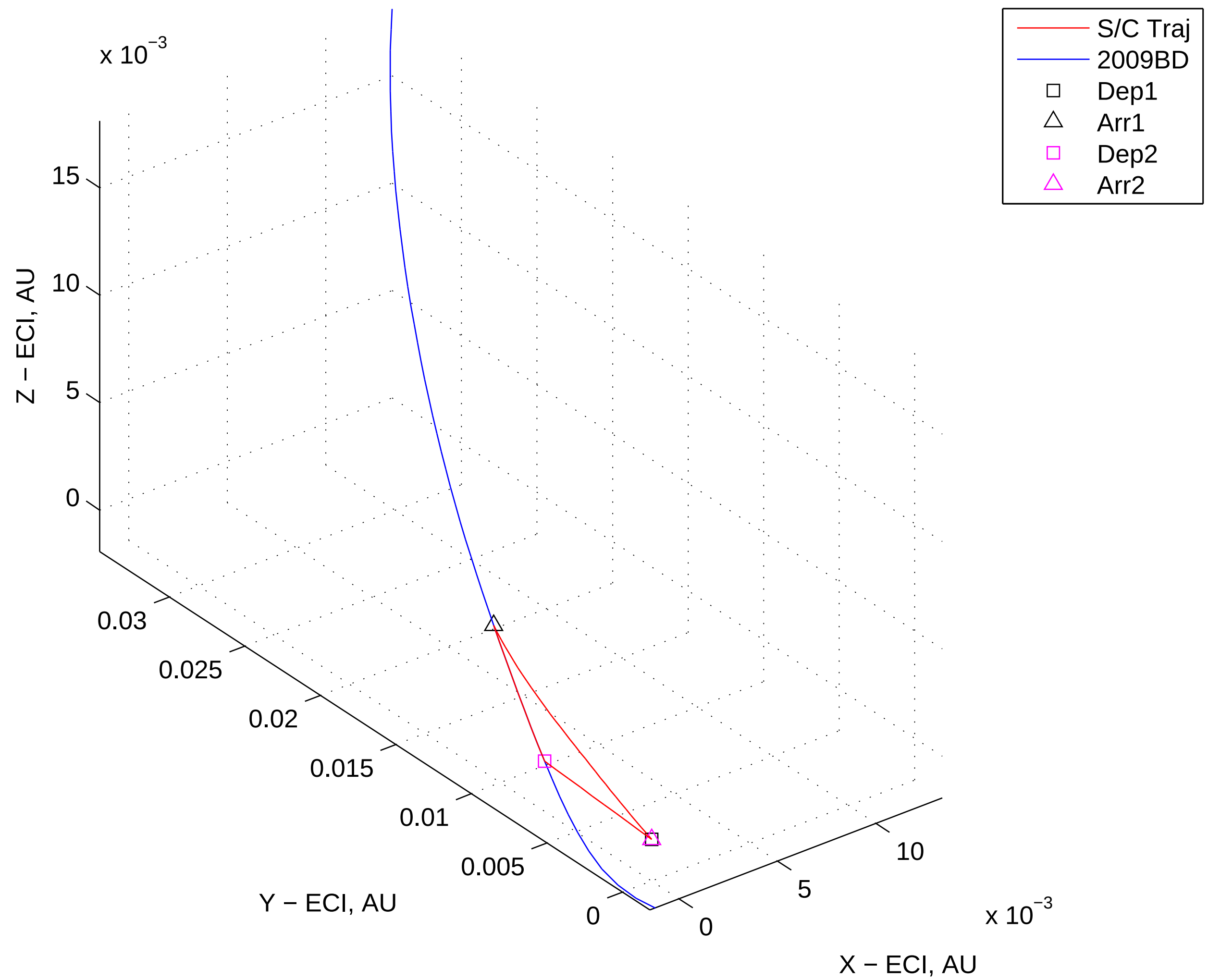
	$\Delta v \leq 12$ km/s, Dur ≤ 450 d				$\Delta v \leq 6.0$ km/s, Dur ≤ 270 d			
	2015–2040		2008–2012		2015–2040		2008–2012	
	Min. Δv	Min. Dur.	Min. Δv	Min. Dur.	Min. Δv	Min. Dur.	Min. Δv	Min. Dur.
Total Δv (km/s)	4.978	11.876	3.464	11.054	5.876	5.964	3.843	**5.998**
Total Duration (days)	370	114	354	18	266	258	258	**50**
Earth Dep Date	30-Nov-2033	25-May-2034	15-Jun-2010	17-May-2011	10-Feb-2034	10-Feb-2034	8-Sep-2009	**15-Apr-2011**
Return Entry Speed (km/s)	11.131	11.909	11.138	11.871	11.181	11.204	11.123	**11.141**

58 Day Mission to 2006 RH_{120}



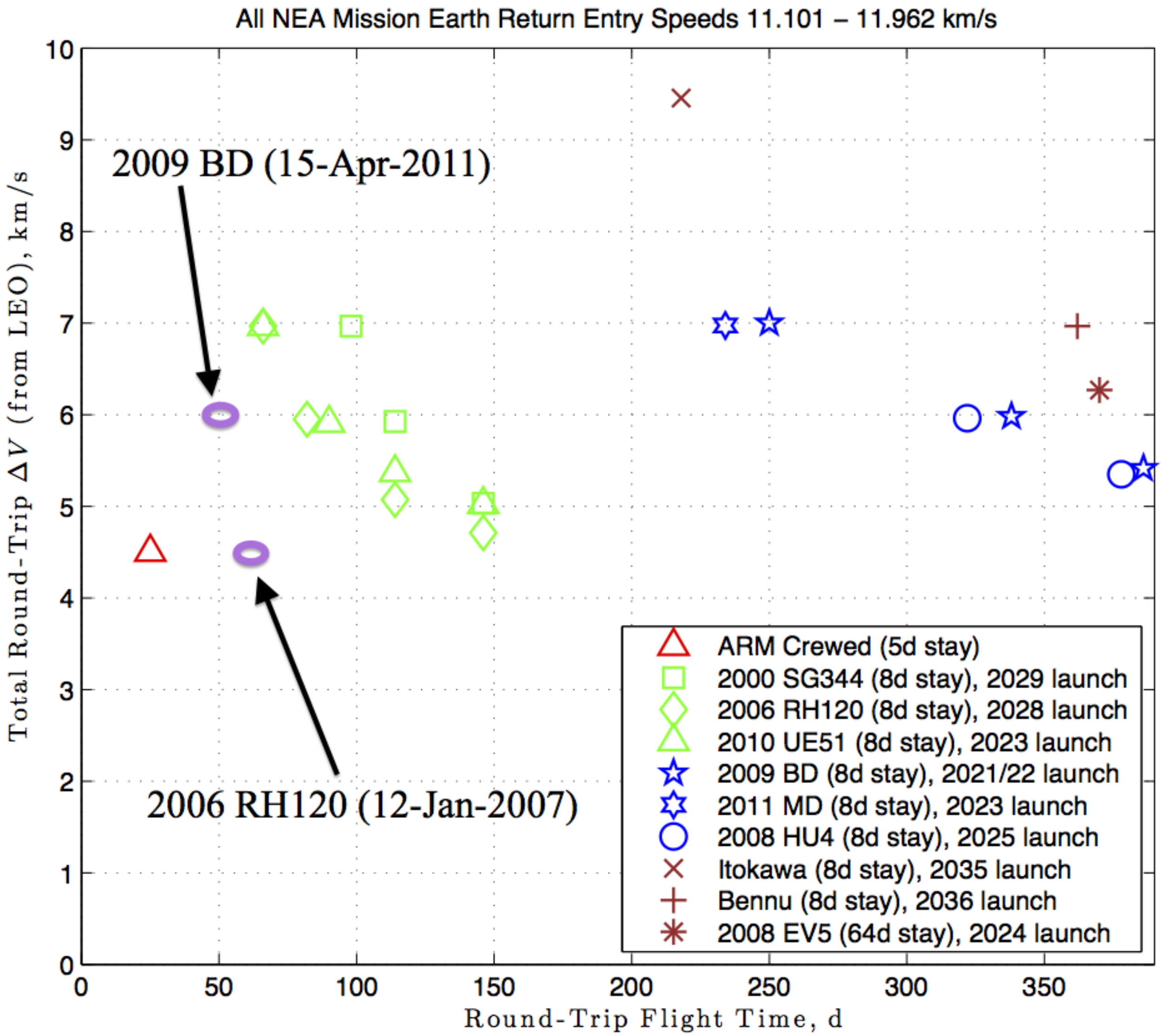
Earth Departure 2007-01-12

50 Day Mission to 2009 BD



Earth Departure 2011-04-15

Comparison to Other NEAs and Lunar DRO



Conclusion

- Missions to 2006 RH_{120} during 2006 and 2007 would not have been feasible, in part because the object was not immediately recognized as a genuine NEA
  - 2006 RH_{120} did not receive its minor planet designation until February 2008, a full year after its peak mission accessibility season
  - A sufficiently long arc of observations is required in order to ascertain whether an object is natural or artificial
- During their discovery time frames, 2006 RH_{120} and 2009 BD were considerably more accessible than even the most accessible of the currently known NEAs
  - The discovery time frame accessibilities of 2006 RH_{120} and 2009 BD approach the accessibility of an object on a lunar DRO
- Thus, it is reasonable to treat 2006 RH_{120} and 2009 BD as proxies for maximally accessible objects
  - In future work we may investigate further by applying the NHATS algorithms to large set of simulated NEAs from current population models

A dedicated space-based NEA survey telescope located away from Earth could discover highly accessible NEAs like 2006 RH_{120} and 2009 BD years in advance of their peak mission accessibility seasons, affording us the opportunity to deploy missions to visit them in their native orbits

NASA